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A new species of *Leposphilus* Hesse, 1866 (Copepoda: Philichthyidae) parasitic in the interorbital canals of the whitemouth croaker *Micropogonias furnieri* (Desmarest) (Sciaenidae) off Brazil with an amended diagnosis of the genus

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Abstract A new species of the monotypic genus *Leposphilus* Hesse, 1866 (Cyclopoida: Philichthyidae), *Leposphilus vogti* n. sp., is described based on adult female and male specimens from the interorbital canals of *Micropogonias furnieri* (Desmarest) (Sciaenidae) in Sepetiba Bay, State of Rio de Janeiro, Brazil. The new species differs from its only congener, *L. labrei* Hesse, 1866, by the following combination of characters in the adult female: a globular cephalosome, a two-segmented maxilla, and fourth abdominal somite fused to caudal ramus; and in the adult male: presence of maxilliped, leg 3 with five setae, and caudal rami tipped with six setae. In addition, an amendment of diagnosis of *Leposphilus* is provided based on the characters of the new species. Previous records of philichthyid copepods from actinopterygians in the Atlantic and Pacific Oceans off the American continent are also given.

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Introduction

The morphology of copepods of the family Philichthyidae, particularly the females, reflects their specialised mode of life (Kabata, 1979; Boxshall & Halsey, 2004). Philichthyids are parasites of subcutaneous spaces associated with the sensory canals of the lateral line and skull bones of marine actinopterygians and rarely elasmobranchs, but differ from true endoparasitic copepods in retaining contact with the external environment *via* a pore of their entry (Boxshall & Halsey, 2004; Madinabeitia et al., 2012).

Currently, this family comprises about 88 species of the following nine genera (Boxshall & Halsey, 2004): *Colobomatoides* Essafi & Raibaut, 1980; *Colobomatus* Hesse, 1873; *Ichthyotaces* Shiino, 1932; *Leposphilus* Hesse, 1866; *Lernaeascus* Claus, 1886; *Philichthys* Steenstrup, 1862; *Procolobomatus* Castro Romero, 1994; *Sarcotaces* Olsson, 1872; and *Sphaerifer* Richardi, 1874. In the western South Atlantic, only five species of two genera have been hitherto recorded: four belonging to *Colobomatus*, i.e. *C. belizensis* Cressey & Schotte, 1983 from *Haemulon steindachneri* (Jordan & Gilbert) and *Orthopristis ruber* (Cuvier); *C. stelliferi* Pombo, Turra, Paschoal & Luque, 2015 from *Stellifer brasiliensis* (Schultz), *S. rastrifer* (Jordan) and *S. stellifer* (Bloch); *C. sudatlanticus* Pereira, Timi, Lanfranchi & Luque, 2012 from *Mullus argentinae* (Hubbs & Marini); *Colobomatus* sp. from *Micropogonias furnieri* (Desmarest); and one species of *Sarcotaces*, i.e. *S. verrucosus* Olsson, 1872 from *Pseudopercis semifasciata* (Cuvier) (González & Tanzola, 2000; Luque & Tavares, 2007; Pereira et al., 2012; Pombo et al., 2015).

The whitemouth croaker *Micropogonias furnieri* (Desmarest) (Sciaenidae) is one of the most commercially important demersal fish species in the South Atlantic Ocean off Brazil with annual catches being over 40,000 metric tons (MPA, 2010; Froese & Pauly, 2015). This species is widely distributed from the Greater Antilles, Caribbean Sea, to the Gulf of San Matias, Argentina, but is particularly abundant on the continental shelf off southeastern Brazil, feeding on benthic crustaceans and sessile mollusks and occasionally fish (Froese & Pauly, 2015). To date, six species of parasitic copepods have been found from this fish in Brazilian waters: *Bomolochus paucus* Cressey & Dojiri, 1984, *Caligus haemulonis* Krøyer, 1863, *Clavellotis dilatata* (Krøyer, 1863), *Colobomatus* sp., *Gauchergasilus euripedesi* (Montú, 1980) and *Neobrachiella chevreuxii* (Van Beneden, 1891) (see Luque & Tavares, 2007).

In this paper, we describe a new species of *Leposphilus* Hesse, 1866 (Cyclopoida: Philichthyidae) based on adult females and males recovered from the interorbital canals of *M. furnieri* caught in Sepetiba Bay, State of Rio de Janeiro, southeastern Brazil. In addition, an amendment of the diagnosis of *Leposphilus* is provided based on the characters of the new species.

Materials and methods

Eight specimens of *M. furnieri* (body length 23–35; mean ± standard deviation 27.6 ± 4.2 cm) were caught in June 2015 in Sepetiba Bay (22°54′–23°04′S, 43°34′–44°10′W), State of Rio de Janeiro, southeastern Brazil. Fish were kept in thermal boxes filled with ice and transported to the laboratory for dissection. Copepods were taken from the interorbital canals of fish, fixed in 70% ethanol and cleared in a drop of 85% lactic acid or lactophenol before examination using a phase-contrast microscope. Specimens were measured intact using an ocular micrometer, dissected and examined according to the wooden slide procedure of Humes & Gooding (1964). Drawings were made with the aid of an Olympus BX51 microscope (Olympus Corporation, Tokyo, Japan) equipped with a drawing tube. Measurements based on six females and four males are given in micrometres, unless otherwise stated, with the range followed by the mean in parentheses. For comparison with *Colobomatus* sp. in *M. furnieri* reported by Alves & Luque (2001), the voucher specimens (MNRJ-14006) from the Crustacea Collection of the National Museum of Rio de Janeiro, Brazil, were examined. The descriptive terminology and classification follow Boxshall & Halsey (2004). The terms prevalence and intensity are used according to Bush et al. (1997). Host identification was based on the key of Menezes & Figueiredo (1980); the nomenclature and classification are updated according to FishBase (Froese & Pauly, 2015). Type-specimens are deposited in the Crustacea Collection of the National Museum of Rio de Janeiro (MNRJ), Brazil, and of the National Museum of Nature and Science, Tsukuba (NSMT-Cr), Ibaraki, Japan.

Order Cyclopoida Burmeister, 1835
Family Philichthyidae Vogt, 1877

***Leposphilus vogti* n. sp.**
Syn. *Colobomatus* sp. of Alves & Luque (2001)

Type-host: Whitemouth croaker *Micropogonias furnieri* (Desmarest) (Perciformes: Sciaenidae).
Type-locality: Sepetiba Bay (22°54′–23°04′S, 43°34′–44°10′W), State of Rio de Janeiro, Brazil.
Prevalence and intensity: 62.5% (five infected out of eight fish examined); mean of 2 copepods per infected fish (range 1–3).
Site in host: Interorbital canals.
Type-material: Holotype: female (MNRJ-26002); allotype: male (MNRJ-26003); paratypes: four females (MNRJ-26004) and two males (MNRJ-26005); another two paratypes: one female (NSMT-Cr 24342) and one male (NSMT-Cr 24343). Two female specimens are kept in the collection of the senior author.
Etymology: The new species is named in honour of Carl Vogt from Germany, for his contribution to knowledge of copepods of the Philichthyidae.

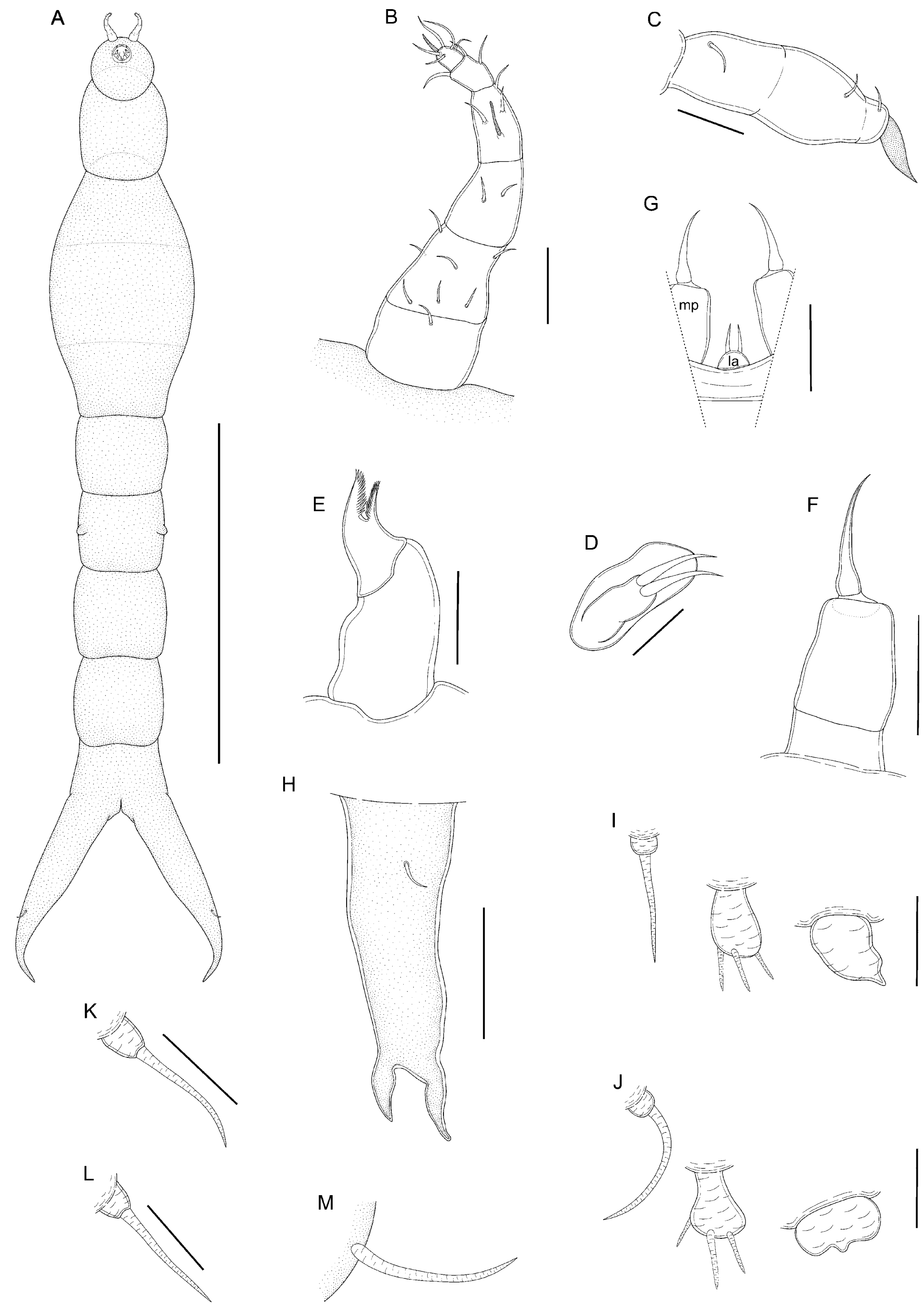

Fig. 1 *Leposphilus vogti* n. sp., adult female. A, Habitus, ventral view; B, Antennule, ventral view; C, Antenna, ventral view; D, Maxillule, ventral view; E, Maxilla, ventral view; F, Maxilliped, ventral view; G, Labium (la) and Maxilliped (mp), ventral view; H, Caudal ramus, lateral view; I, Leg 1, ventrolateral view; J, Leg 2, ventrolateral view; K, Leg 3, ventrolateral view; L, Leg 4, ventrolateral view; M, Leg 6, ventrolateral view. *Scale-bars*: A, 4 mm; B, H, 100 μm; C–D, I, J–M, 20 μm; E–F, 40 μm; G, 50 μm

Description (Figs. 1–3)

Adult female

Body elongate without processes (Fig. 1A), 9.01–10.41 (9.92) mm long. Cephalosome globular, 580–925 × 650–950 (716 × 762). First pedigerous somite cylindrical, with slightly convex lateral margins, 1.12–1.91 × 0.82–1.15 (1.34 × 0.97) mm. Second to fourth pedigerous somites swollen, forming octagonal to ovoid thoracic region, 1.68–3.35 (2.51) mm long, representing about 22% of total body length, 1.01–1.40 (1.20) mm wide. First to fourth pairs of legs located ventrolaterally. Fifth pedigerous somite narrower posteriorly, separated from preceding fused somites by slight constriction, 790–820 × 850–900 (805 × 878). Genital somite ovoid, bearing pair of lateral swellings, 750–810 × 815–900 (780 × 853). Abdomen 3-segmented (Fig. 1A), abdominal somites wider than long and ending towards into caudal rami, measuring 725–800 × 875–925 (770 × 900), 750–825 × 800–975 (792 × 885), 650–750 × 825–950 (710 × 891), respectively. Caudal ramus fused to last abdominal somite (Fig. 1A), with 2 fused setal elements at tip and 1 lateral seta in middle part (Fig. 1H), 1.75–2.25 (1.95) mm long.

Antennule (Fig. 1B) apparently 6-segmented, aesthetascs present on fourth and sixth segments; setal formula as follows: 1: 7: 2: 3 + 1 aesthetasc: 3: 5 + 1 aesthetasc; all setae naked. Buccal area forming tube-like capsule covered anteriorly by antennae and bordered posteriorly by labium. Antenna (Fig. 1C) unmodified, uniramous and apparently 3-segmented; basal segment with anteromedial naked seta; second segment with distomedial naked seta; distal segment short, with 1 distomedial naked seta and 1 thin-walled, blunt element. Labrum not seen. Maxillule (Fig. 1D) minute, 1-segmented, located mid-laterally in buccal area and bearing 2 apical setae. Maxilla (Fig. 1E) robust, 2-segmented; basal segment large and unarmed; distal segment terminating in two subequal, spinulose spines. Maxilliped (Fig. 1F) 3-segmented; all segments unarmed; distal segment forming long apical spine. Labium (Fig. 1G) divided, tapering into sharp tips, located between pair of maxillipeds.

Legs 1–2 small and inserted in rugose area. Leg 1 (Fig. 1I) biramous, located immediately posterior to junction of cephalosome and first pedigerous somite; protopod fused to somite and carrying 1 annulated seta arising from basal protrusion; endopod vestigial, unsegmented and unarmed; exopod appearing unsegmented, armed with 3 distal setae. Leg 2 (Fig. 1J) biramous, located immediately posterior to junction of first pedigerous somite and swollen somites (second pedigerous somite); protopod fused to somite and carrying 1 annulated seta arising from basal protrusion; endopod vestigial, unsegmented and unarmed; exopod appearing unsegmented, armed with 1 lateral seta and 2 distal setae. Leg 3 (Fig. 1K) vestigial, located in second part of swollen somites (third pedigerous somite) and represented by single annulated seta on small papilla. Leg 4 (Fig. 1L) vestigial, located in third part of swollen somites (fourth pedigerous somite) and represented by single annulated seta on small papilla. Leg 5 absent. Leg 6 (Fig. 1M), located near genital apertures, represented by single annulated seta.

Adult male

Body cylindrical and not transformed (Fig. 2A), 2.01–2.07 (2.04) mm long. Cephalosome with transverse sclerotised band posterodorsally and rounded posterolateral corners (Fig. 2A), 329–357 × 388–396 (342 × 391). First pedigerous somite wider than long, 130–140 × 458–474 (135 × 464). Second pedigerous somite wider than long, 147–151 × 452–470 (149 × 463), with paired dorsolateral processes directed backwards, distal part recurved dorsally, hook-like (Fig. 2A), 185–190 (187) long. Third to fifth pedigerous somites each wider than long, measuring 102–132 × 425–432 (115 × 428), 152–163 × 368–400 (157 × 379), 166–179 × 354–372 (173 × 363), respectively. Genital somite not expanded, with 2 setae on posterolateral corner of genital operculum, 176–193 × 332–336 (184 × 334). Abdomen four-segmented, first 3 abdominal somites wider than long, measuring 210–223 × 297–313 (212 × 305), 216–217 × 276–277 (216 × 276), 178–183 × 203–206 (180 × 204), respectively. Last abdominal somite longer than wide, 198–223 × 198–206 (211 × 202). Caudal rami, 242–247 (244) long, 4.25 times long as wide, each ramus armed with 6 setae (Fig. 2I), 1 lateral on outer margin, 1 ventrolateral on inner margin, and 4 terminal setae of unequal size, 2 medial in opposite corners and 2 long apical, longest setae measuring 236–268 (250) long.

Rostrum absent. Antennule (Fig. 2B), 6-segmented, aesthetascs present on fifth and sixth segments; setal formula as follows: 1: 4: 5: 4: 2 + 1 aesthetasc: 7 + 1

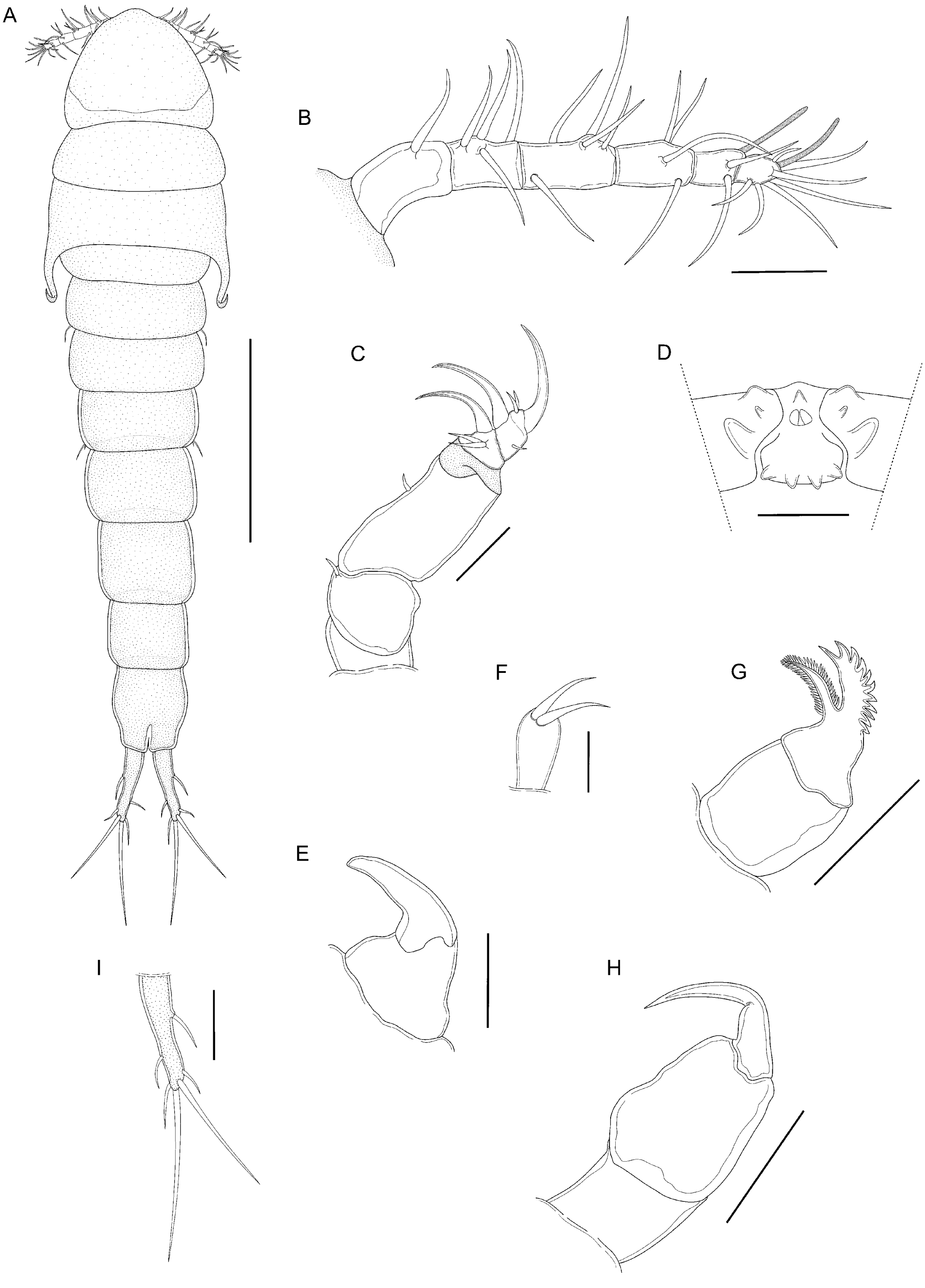

Fig. 2 *Leposphilus vogti* n. sp., adult male. A, Habitus, dorsal view; B, Antennule, ventral view; C, Antenna, dorsal view; D, Labrum, ventral view; E, Mandible, ventral view; F, Maxillule, ventral view; G, Maxilla, ventral view; H, Maxilliped, lateral view; I, Caudal ramus, ventral view. *Scale-bars*: A, 500 µm; B, E, 40 µm; C, G, H, 50 µm; D, F, 20 µm; I, 100 µm

aesthetasc; all setae naked. Antenna (Fig. 2C) 5-segmented and consisting of coxa, basis, and 3-segmented endopod; short coxa unarmed; basis with 1 small seta; first endopodal segment elongate with 1 small seta, distal part thick; second endopodal segment with 1 large claw and 2 medial setae; third endopodal segment with 2 large claws, 1 small seta and 2 medial setae. Labrum (Fig. 2D) much reduced, ventral surface armed with 1 anterior tooth and 4 posterior stout teeth of identical size; lateral regions of labrum sclerotised, with 2 blunt humps and 1 small tooth. Mandible (Fig. 2E) large, comprising broad based coxa and distal claw-like blade. Maxillule (Fig. 2E) 1-segmented, with 2 spinulose setae distally. Maxilla (Fig. 2G) 2-segmented; basal segment unarmed; distal segment terminating in 2 subequal, spinulose spines. Maxilliped (Fig. 2H) 3-segmented, all segments unarmed, terminal segment forming long apical spine.

Swimming legs 1 (Fig. 3A) and 2 (Fig. 3B) biramous, each with 2-segmented protopod comprising coxa and basis; interpodal plates lacking spinules; coxa with inner seta and smooth margins; basis with an outer seta present on posterior surface. Rami 2-segmented with outer margins of endopods and inner margins of exopods setulate. Spines on exopods denticulate, but fourth and third exopod spines on the second segment on legs 1 and 2, respectively, with denticulate outer margin and setulate inner margin.

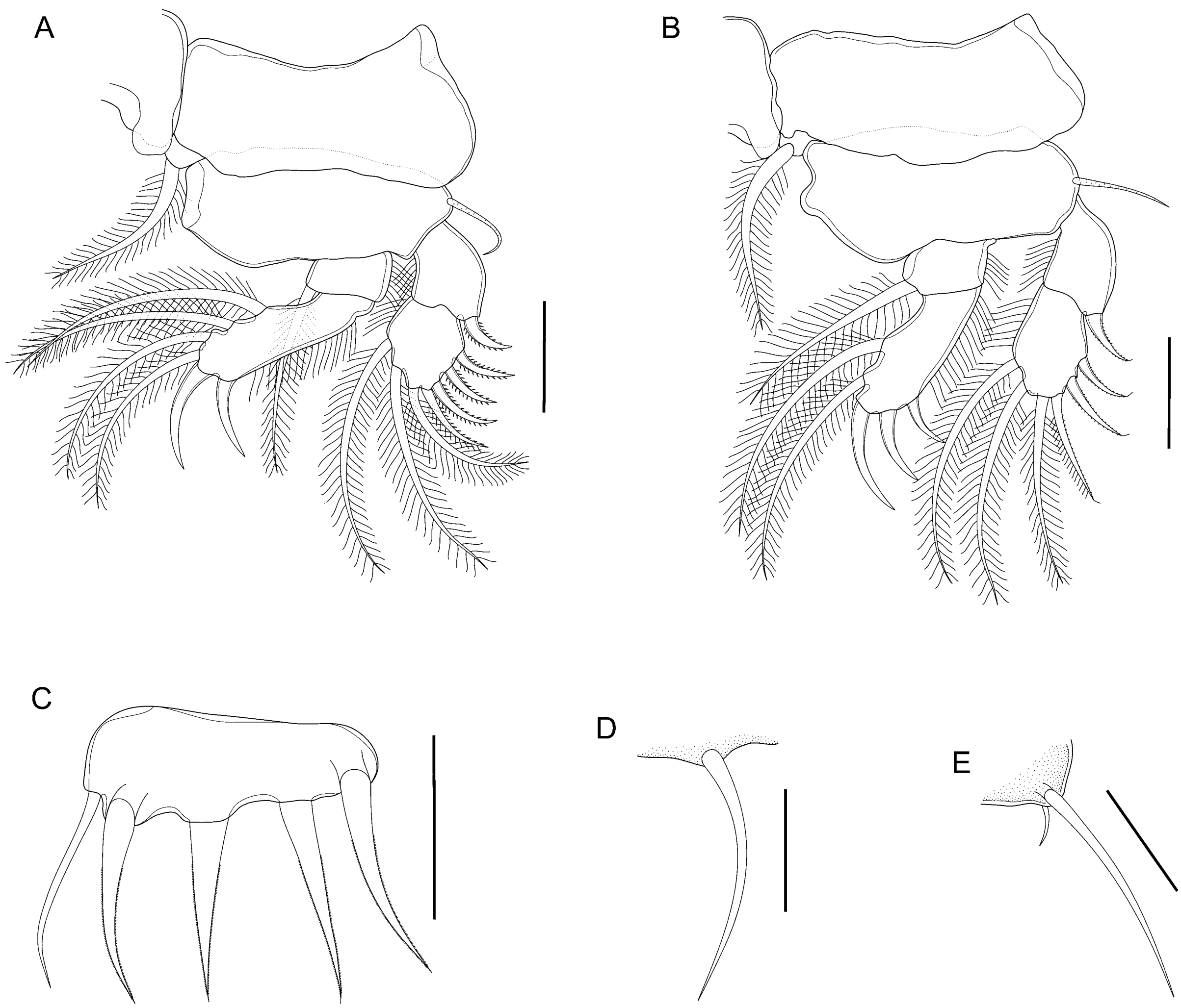

Fig. 3 *Leposphilus vogti* n. sp., adult male. A, Leg 1, ventral view; B, Leg 2, ventral view; C, Leg 3, ventral view; D, Leg 4, ventrolateral view; E, Leg 6, ventrolateral view. *Scale-bars*: 50 µm

Armature of legs (spines, Roman numerals; setae, Arabic numerals) as follows:

	Coxa	Basis	Exopod	Endopod
Leg 1	0–1	1–0	I–0; IV–3	0–1; II–4
Leg 2	0–1	1–0	I–0; III–3	0–1; III–2

Leg 3 (Fig. 3C) uniramous, wider than long, armed with 1 naked inner seta and 4 spinulose distal setae. Leg 4 (Fig. 3D) vestigial, represented by 1 naked ventrolateal seta on fourth pedigerous somite. Leg 5 absent. Leg 6 (Fig. 3E), represented by 2 unequal setae on genital operculum of genital somite.

Remarks

According to Boxshall & Halsey (2004) the Philichthyidae can be included in a group of families with the Chondracanthidae, Shiinoidae and Lernaeosoleidae, especially by the presence of two toothed elements only on the mandible, the reduction of legs 4 and 5, and the presence of one and two geniculate claws, respectively, on the second and third endopodal segments of the antenna in the first copepodid stage. Nevertheless, the philichthyids can be separated from these families based on the morphology of body shape in the adult female; the body can be elongate, flattened or highly irregular with numerous processes (Boxshall & Montú, 1997; Pombo et al., 2015). The adult females examined in the present study are identified as belonging to *Leposphlilus* by their possession of the following combination of characters: an elongated body without lateral processes; an abdomen ending in paired caudal rami; and a swollen middle section of the body comprising the second to fourth pedigerous somites (Kabata, 1979; Boxshall & Halsey, 2004).

At present, only *L. labrei* Hesse, 1866, is known in this genus, parasitising fishes of the family Labridae, i.e. *Centrolabrus exoletus* (Linnaeus), *Coris julis* (Linnaeus), *Labrus bergylta* Ascanius, *Symphodus melops* (Linnaeus), *S. mediterraneus* (Linnaeus), *S. rostratus* (Bloch) and *S. tinca* (Linnaeus) from European waters (Hesse, 1866; Quidor, 1910; Monod, 1923; Delamare Deboutteville, 1962; Quignard, 1968; Holmes, 1987; Raibaut et al., 1998). The adult female of *L. labrei* can be easily differentiated from *L. vogti* n. sp. by an elongated cephalosome with a truncated distal part (*vs* globular in the new species), a three-segmented maxilla (*vs* two-segmented in the new species), and four abdominal somites (*vs* three abdominal somites in the new species: the fourth abdominal somite is fused to the caudal ramus) (Vogt, 1877; Delamare Deboutteville, 1962; Yamaguti, 1963). Compared to the adult male, *L. labrei* can be differentiated from *L. vogti* n. sp. by the absence of maxilliped (*vs* present in the new species), leg 3 with three setae (*vs* five setae in the new species) and caudal rami tipped with five setae (*vs* caudal rami tipped with six setae in the new species) (Vogt, 1877).

The morphology of males in the Philichthyidae is one of the most important and unifying family characteristics (Delamare Deboutteville, 1962; Kabata, 1979). The males of *Leposphilus* resemble those of *Colobomatus* and *Philichthys* and share the same general morphology of the second pedigerous somite (a pair of dorsolateral processes directed backwards), armature of legs 1 and 2 (biramous with distinctly two-segmented rami bearing spines and setae) and an uniramous leg 3 (Kabata, 1979; West, 1992; Castro Romero, 1994). However, the presence of six setae on the caudal rami and five elements on leg 3 in *L. vogti* n. sp. is shared only by *C. embiotocae* Noble, Collard & Wilkes, 1969, from an embiotocid fish in American waters (Noble et al., 1969) and *C. similis* Kim, 1995 from *Ditrema temminckii* Bleeker (Embiotocidae) in Asian waters (Kim, 1995). The males of *C. embiotocae* and *C. similis* differ from that of *L. vogti* n. sp. in the absence of leg 4 (Noble et al., 1969; Kim, 1995), and the male of the new species possesses one naked ventrolateral seta on the fourth pedigerous somite. Additionally, *L. vogti* n. sp. is separated from *C. embiotocae* in the absence of an outer seta on the posterior surface of the basis (*vs* presence in the new species) and from *C. similis* by the presence of one small seta on the inner margin of the coxa (*vs* absence in the new species) (Noble et al., 1969; Kim, 1995).

Hesse (1866) described for the first time a member of *Leposphilus* and proposed that it was placed in a separate family, the Lerneosiphonostomiens, a name never used subsequently (see Kabata, 1979). Later, Vogt (1877) transferred Hesse's species to the Philichthyidae and described *L. labrei* as a new species, focusing on the mouthparts in the female and some important features of the male, e.g. the arrangement of the legs. Since Vogt's (1877) publication, few studies have been conducted on this philichthyid group. Delamare Deboutteville (1962) reviewed the genera in the Philichthyidae, addressing mainly the body plan and Yamaguti (1963) proposed the new diagnosis of *Leposphilus* but only for females. Thus the description of *L. vogti* n. sp. can be helpful in understanding some features in this genus, such as the body plan and arrangement of the small appendages.

The females of *L. vogti* n. sp. and *L. labrei* exhibit some similar features, *viz.* the second to fourth swollen pedigerous somites, lack of lateral processes in the body, a buccal area composed by the antenna, maxillule, maxilla, maxilliped, and a divided labium (see Vogt, 1877). However, the main difference between the morphological characters of the new species and the generic diagnosis proposed by Yamaguti (1963) is the presence of legs 1 to 4 and 6 in female (reported as absent in Yamaguti, 1963). The legs were probably overlooked in the descriptions of Hesse (1866) and Vogt (1877) due to their small size, and several members of the Philichthyidae described in the 19th Century lack information on legs.

The males of both species have similar characters, such as a six-segmented antennule, biramous legs 1 and 2 and uniramous leg 3, but differ from each other in the maxilliped, i.e. present in the new species but absent in *L. labrei* (see Vogt, 1877). This condition, however, is not atypical in the family and is seen in the males of *Colobomatus*, e.g. *C. cresseyi* West, 1992 and *C. nanus* West, 1992 (see West, 1992). According to Delamare Deboutteville (1962), the abdomen of male philichthyids is almost always four-segmented, but that of the male of *Leposphilus* shows a loss of division between the third and fourth somites (see Kabata, 1979). Nonetheless, this loss of division cannot be found in the new species and also in the line drawings of *L. labrei* by Vogt (1877), where the male has 11 distinct segments, comprising the cephalosome, five free pedigerous somites, the genital somite and a four-segmented abdomen, but a small depression is observed in the middle of the fourth abdominal somite, which was maybe caused by a fold in the animal or an error in drawings. There was probably a misinterpretation by Delamare Deboutteville (1962) in relation to this depression, confusing it for the division of the last segment and proposed a loss of division between the third and fourth segment of the abdomen.

Based on the above remarks and the new morphological data in this paper, the diagnosis of *Leposphilus* is amended below:

Leposphilus Hesse, 1866

Diagnosis

Podoplean copepods with elongate body without lateral processes in adult female. Body of adult male body slender, with distinct segmentation. Body in both sexes comprising cephalosome, 5 free pedigerous somites, genital somite and 4-segmented abdomen. Pedigerous somites 2 to 4 in female swollen. Male with pair of dorsal processes on second pedigerous somite. Genital apertures dorsolateral on genital somite in female; ventral in male. Caudal rami tipped with setae. Antennule 2, 3 or 6-segmented in female; 6-segmented in male; typically with aesthetasc on apical segment. Antenna indistinctly 2 or 3-segmented in female and 5-segmented in male, comprising, coxa, basis and 3-segmented endopod. Labrum enclosed within buccal capsule formed by antennae and a posterior cuticular fold. Mandible unsegmented with falcate blade in male, missing in female. Maxillule small, unilobate; sometimes with two apical setae. Maxilla 2 or 3-segmented; with two spines apically; sometimes with seta proximally. Maxilliped 3-segmented, bearing an apical spine; sometimes absent in male. Swimming legs 1 and 2 biramous; 2-segmented rami in male; leg 3 uniramous in male; vestigial in female; leg 4 vestigial, represented by seta(e). Leg segmentation more distinct in males. Inner coxal seta present or absent in legs 1 and 2 of male. Fifth leg absent. Leg 6 near genital apertures, represented by seta(e). Egg-sacs lying along outer margin of pedigerous somites 2 to 5.

Type-species: *Leposphilus labrei* Hesse, 1866.

Discussion

Of the nine known genera in the Philichthyidae, *Leposphilus* is the second oldest genus and its members resemble the species of *Lerneascus*, mainly in the absence of lateral processes of the body (Boxshall & Halsey, 2004). The females of *Leposphilus* spp., however, can be differentiated from those of *Lerneascus* by possessing a swollen middle section of the body comprising the second to fourth pedigerous somites, while *Lerneascus* have a swollen anterior part of the body from the cephalothorax to the genital somite (Kabata, 1979; Boxshall & Halsey, 2004). In this study, we describe the female and male of *L. vogti* n. sp. from the interorbital canals of *Micropogonias furnieri*. Before this study, Alves & Luque (2001) examined 100 specimens of *M. furnieri* collected in the same locality (Sepetiba Bay) and recorded *Colobomatus* sp. from the gills of one specimen. We could make a comparison with the specimens of *Colobomatus* sp. loaned from the National Museum of Rio de Janeiro and found that this material and the specimens of *L. vogti* n. sp. are identical. Probably, Alves & Luque (2001) did not observe the absence of lateral processes in the female body and identified their specimens as *Colobomatus* sp. Moreover, the site of infection reported as the gills by Alves & Luque (2001) needs confirmation because philichthyid copepods are internal parasites of subcutaneous spaces (see Boxshall & Halsey, 2004) and all the specimens in this study were found in the host's interorbital canals.

Records of philichthyids from American waters are scarce and most records are dispersed in the literature. Currently, 18 species (including *L. vogti* n. sp.) belonging to five of the nine philichthyid genera, i.e. *Colobomatus* (ten spp.), *Sarcotaces* (four spp.), *Procolobomatus* (two spp.) and *Philichthys* (one sp.), have been reported in the Atlantic and Pacific Oceans off the American continent (Table 1), accounting for 20% of the global diversity of this family. Similar results

Table 1 Records of species of the Philichthyidae Hesse, 1877 parasitic in marine fish in American waters

Parasite species	Host species (Family)	Site in host	Distribution	Reference
Colobomatus belizensis Cressey & Schotte, 1983	*Haemulon aurolineatum* Cuvier (Haemulidae)	Mandibular canals	Brazil (unspecified); USA (Florida)	Cressey & Schotte (1983); Luque & Tavares (2007); Paschoal et al. (2015)
	Haemulon carbonarium Poey (Haemulidae)	Mandibular canals	Dominica (unspecified); Panama (unspecified)	Cressey & Schotte (1983); Paschoal et al. (2015)
	Haemulon chrysargyreum Günther (Haemulidae)	Mandibular canals	Bahamas (Abaco); Barbados (unspecified); USA (Key West, Florida); Saint Lucia (unspecified)	Cressey & Schotte (1983); Paschoal et al. (2015)
	Haemulon macrostomum Günther (Haemulidae)	Mandibular canals	Panama (unspecified)	Cressey & Schotte (1983); Paschoal et al. (2015)
	Haemulon melanurum (Linnaeus) (Haemulidae)	Mandibular canals	Bahamas (West Indies) and Guyana (unspecified)	Cressey & Schotte (1983); Paschoal et al. (2015)
	Haemulon parra (Desmarest) (Haemulidae)	Mandibular canals	Panama (Toro Point)	Cressey & Schotte (1983); Paschoal et al. (2015)
	Haemulon plumierii (Lacépède) (Haemulidae)	Mandibular canals	Cuba (Havana); Colombia (Caribbean); Mexico (Cozumel); USA (Virgin Islands)	Cressey & Schotte (1983); Morales-Serna et al. (2012); Paschoal et al. (2015); Varela & Lalana (2015)
	Haemulon sciurus (Shaw) (Haemulidae)	Mandibular canals	Bahamas (West Indies); Belize (Carrie Bow Cay); Cuba (Havana); Mexico (Cozumel, Yucatan); USA (Florida, Dry Tortugas)	Cressey & Schotte (1983); Morales-Serna et al. (2012); Paschoal et al. (2015); Varela & Lalana (2015)
	Haemulon steindachneri (Jordan & Gilbert) (Haemulidae)	Mandibular canals	Brazil (Rio de Janeiro); Colombia (Caribbean)	Cressey & Schotte (1983); Luque & Takemoto (1996); Paschoal et al. (2015)

Table 1 continued

Parasite species	Host species (Family)	Site in host	Distribution	Reference
C. belizensis	*Orthopristis chrysoptera* (Linnaeus) (Haemulidae)	Mandibular canals	USA (Louisiana, North Carolina)	Cressey & Schotte (1983); Paschoal et al. (2015)
	Orthopristis ruber (Cuvier) (Haemulidae)	Mandibular canals	Guyana (unspecified); Venezuela (unspecified)	Cressey & Schotte (1983); Paschoal et al. (2015)
C. caribbei Cressey & Schotte, 1983	*Anisotremus surinamensis* (Bloch) (Haemulidae)	Mandibular canals	Panama (unspecified); USA (Florida); Venezuela (unspecified)	Cressey & Schotte (1983); Paschoal et al. (2015)
C. embiotocae Nobel, Collard & Wilkes, 1969	*Amphistichus argenteus* Agassiz (Embiotocidae)	Under skin covering bony ridges of head, and cephalic sensory canal system	USA (Point Conception, Gaviota, Malibu)	Noble et al. (1969)
	Amphistichus koelzi (Hubbs) (Embiotocidae)	Under skin covering bony ridges of head, and cephalic sensory canal system	USA (Gaviota)	Noble et al. (1969)
	Cymatogaster aggregata Gibbons (Embiotocidae)	In left hyomandibular preopercular suture and mucuos canals	Mexico (Baja California); USA (Goleta, San Diego, Santa Barbara, San Francisco)	Noble et al. (1969); Arai et al. (1988); Morales-Serna et al. (2012)
	Embiotoca lateralis Agassiz (Embiotocidae)	Under skin covering bony ridges of head, and cephalic sensory canal system	USA (Point Conception)	Noble et al. (1969)
	Hyperprosopon argenteum Gibbons; *Hypsurus caryi* (Agassiz); *Micrometrus minimus* (Gibbons); *Rhacochilus toxotes* Agassiz (Embiotocidae)	Under skin covering bony ridges of head and cephalic sensory canal system	USA (Goleta)	Noble et al. (1969)
	Rhacochilus vacca (Girard) (Embiotocidae)	Under skin covering bony ridges of head	USA (Malibu)	Noble et al. (1969)
C. goodingi Cressey & Collette, 1970	*Ablennes hians* (Valenciennes) (Belonidae)	Cephalic canals	Cuba (unspecified); Haiti (unspecified); Mexico (Acapulco); Panama (Pacific)	Cressey & Collette (1970); Morales-Serna et al. (2012)
	Strongylura exilis (Girard) (Belonidae)	Cephalic canals	Panama (Pacific)	Cressey & Collette (1970)
	Strongylura marina (Walbaum) (Belonidae)	Cephalic canals	USA (Everglades National Park, Clearwater, Alligator Harbour, Panama City, Florida)	Cressey & Collette (1970)
	Strongylura notata (Poey) (Belonidae)	Cephalic canals	Bahamas (unspecified); Bimini (Caribbean Sea); USA (Sanibel Island, Sarasota, Tampa Bay, Alligator Harbour, Key Biscayne, Florida)	Cressey & Collette (1970)
	Strongylura timucu (Walbaum) (Belonidae)	Cephalic canals	Curaçao; Haiti; USA (Florida, Virgin Islands)	Cressey & Collette (1970)
	Tylosurus acus (Lacépède) (Belonidae)	Cephalic canals	Bahamas (unspecified); Mexico (Acapulco, Gulf of Mexico); Panama (Pacific); Peru (Cabo Blanco)	Cressey & Collette (1970); Morales-Serna et al. (2012)
	Tylosurus crocodilus (Péron & Lesueur) (Belonidae)	Cephalic canals	Trinidad and Tobago (Trinidad); USA (Virginia Key, Florida); Venezuela (unspecified)	Cressey & Collette (1970)

Table 1 continued

Parasite species	Host species (Family)	Site in host	Distribution	Reference
C. miniprocessus Castro Romero & Muñoz, 2011	*Anisotremus scapularis* (Tschudi) (Haemulidae)	Mandibular canals	Chile (Antofagasta)	Castro Romero & Muñoz (2011)
C. quadrifarius Cressey & Schotte, 1983	*Anisotremus davidsonii* (Steindachner) (Haemulidae)	Mandibular canals	Mexico (Sonora)	Cressey & Schotte (1983); Morales-Serna et al. (2012); Paschoal et al. (2015)
	Anisotremus interruptus (Gill) (Haemulidae)	Mandibular canals	Mexico (Nayarit)	Cressey & Schotte (1983); Morales-Serna et al. (2012); Paschoal et al. (2015)
	Genyatremus dovii (Günther) (Haemulidae)	Mandibular canals	Colombia (Pacific); Panama (Pacific)	Cressey & Schotte (1983); Paschoal et al. (2015)
	Genyatremus pacifici (Günther) (Haemulidae)	Mandibular canals	El Salvador (unspecified); Guatemala (unspecified)	Cressey & Schotte (1983); Paschoal et al. (2015)
	Haemulon flaviguttatum Gill (Haemulidae)	Mandibular canals	Mexico (Baja California); Panama (Pacific)	Cressey & Schotte (1983); Morales-Serna et al. (2012); Paschoal et al. (2015)
	Haemulon steindachneri (Haemulidae)	Mandibular canals	Mexico (Colima, Cape St. Lucas)	Cressey & Schotte (1983); Morales-Serna et al. (2012); Paschoal et al. (2015)
	Orthopristis chalceus (Günther) (Haemulidae)	Mandibular canals	Ecuador (Galapagos)	Cressey & Schotte (1983); Paschoal et al. (2015)
C. springeri Cressey, 1977	*Cryptotrema corallinum* Gilbert (Labrisomidae)	Interorbital canals	USA (Santa Catalina Islands, California)	Cressey (1977)
C. stelliferi Pombo, Turra, Paschoal & Luque, 2015	*Stellifer brasiliensis* (Schultz); *Stellifer rastrifer* (Jordan); *Stellifer stellifer* (Bloch) (Sciaenidae)	Mandibular canals	Brazil (Caraguatatuba Bay, State of São Paulo)	Pombo et al. (2015)
C. sudatlanticus Pereira, Timi, Lanfranchi & Luque, 2012	*Mullus argentinae* Hubbs & Marini (Mullidae)	Pores of cephalic sensory system and nostrils	Argentina (Mar del Plata); Brazil (Florianopolis, State of Santa Catarina; coastal waters off Rio de Janeiro State; and coastal waters off Rio Grande, State of Rio Grande do Sul)	Pereira et al. (2012); Luque et al. (2013)
C. tenuis Castro Romero & Muñoz, 2011	*Scartichthys viridis* (Valenciennes); *Scartichthys gigas* (Steindachner) (Bleniidae); *Auchenionchus variolosus* (Valenciennes) (Labrisomidae)	Mucous canals of opercular bones	Chile (Valparaiso, Antofagasta)	Castro Romero & Muñoz (2011)
Leposphilus vogti n. sp.	*Micropogonias furnieri* (Desmarest) (Sciaenidae)	Interorbital region	Brazil (Sepetiba Bay, State of Rio de Janeiro)	This study
Philichthys xiphiae Steenstrup, 1862	*Xiphias gladius* Linnaeus (Xiphiidae)	Cephalic canals	USA (North Atlantic waters)	Ho (1978)
Procolobomatus hemilutjani Castro Romero, 1994	*Hemilutjanus macrophthalmos* (Tschudi) (Serranidae)	Mandibular mucus ducts	Chile (Antofagasta)	Castro Romero (1994); Muñoz & Olmos (2007)

Table 1 continued

Parasite species	Host species (Family)	Site in host	Distribution	Reference
P. kyphosus (Sekerak, 1970)	*Sebastes aleutianus* (Jordan & Evermann); *Sebastes borealis* Barsukov (Sebastidae)	Cephalic sensory canals	Canada (British Columbia); USA (Gulf of Alaska)	Sekerak & Arai (1977); Kabata (1988); Moles et al. (1998)
	Sebastes alutus (Gilbert) (Sebastidae)	Cephalic sensory canals system	Canada (Vancouver Island)	Sekerak (1970); Kabata (1988)
P. kyphosus (Sekerak, 1970)	*Sebastes babcocki* (Thompson); *Sebastes brevispinis* (Bean); *Sebastes caurinus* Richardson; *Sebastes crameri* (Jordan); *Sebastes diploproa* (Gilbert); *Sebastes elongatus* Ayres; *Sebastes entomelas* (Jordan & Gilbert); *Sebastes flavidus* (Ayres); *Sebastes maliger* (Jordan & Gilbert); (Sebastidae)	Cephalic sensory canals system	Canada (British Columbia)	Sekerak & Arai (1977); Kabata (1988)
P. kyphosus (Sekerak, 1970)	*Sebastes nigrocinctus* Ayres; *Sebastes pinniger* (Gill); *Sebastes proriger* (Jordan & Gilbert); *Sebastes reedi* (Westrheim & Tsuyuki); *Sebastes ruberrimus* (Cramer); *Sebastes variegatus* Quast; *Sebastes zacentrus* (Gilbert) (Sebastidae)	Cephalic sensory canals system	Canada (British Columbia)	Sekerak & Arai (1977); Kabata (1988)
Sarcotaces arcticus Collett, 1874	*Sebastes aleutianus* and *Sebastes brevispinis* (Sebastidae)	Encysted in body cavity, musculature	Canada (British Columbia)	Sekerak & Arai (1977); Kabata (1988)
	Sebastes auriculatus Girard (Sebastidae)	Body cavity near anus	USA (Tiburon, California)	Moser et al. (1985)
	Sebastes alutus (Sebastidae)	Encysted in body cavity, musculature	Canada (British Columbia)	Liston et al. (1960); Sekerak (1970); Hoskins & Hulstein (1977); Sekerak & Arai (1977); Kabata (1988)
	Sebastes ciliatus (Tilesius) (Sebastidae)	Body cavity near anus	USA (Southeast Alaska)	Moser et al. (1985)
	Sebastes entomelas; *Sebastes flavidus*; *Sebastes melanops* Girard (Sebastidae)	Body cavity near anus	USA (Monterey Bay, California)	Moser et al. (1985)
	Sebastes ruberrimus (Sebastidae)	Encysted in body cavity, musculature	Canada (British Columbia)	Kuitunen-Ekbaum (1949); Hoskins et al. (1976); Sekerak & Arai (1977); Kabata (1988)
	Sebastes semicinctus (Gilbert) (Sebastidae)	Body cavity near anus	USA (Los Angeles)	Moser et al. (1985)
	Sebastes serranoides (Eigenmann & Eigenmann) (Sebastidae)	Body cavity near anus	USA (San Luis Obispo, Farron Island, California)	Love et al. (1984); Moser et al. (1985)
S. komaii Shiino, 1953	*Sparisoma rubripinne* (Valenciennes) (Scaridae)	Abdominal cavity	Cuba (Havana)	Ezpeleta (1974); Varela & Lalana (2015)

Table 1 continued

Parasite species	Host species (Family)	Site in host	Distribution	Reference
S. verrucosus Olsson, 1872	*Pseudopercis semifasciata* (Cuvier) (Pinguipedidae)	Encysted in abdominal region	Argentina (Gulf of San Matias)	González & Tanzola (2000)
	Halichoeres radiatus (Linnaeus) (Labridae)	Encysted in body sides	Martinique (unspecified)	Dollfus (1928)
Sarcotaces sp.	*Physiculus rastrelliger* Gilbert (Pinguipedidae)	Encysted in abdominal region	El Salvador (unspecified)	Moser (1977)

were found by Madinabeitia & Iwasaki (2013) who tabulated 20 species of philichthyids from Asian waters, accounting for 25% of the total. In fact, many records of philichthyids are from the Mediterranean Sea and Australian waters, but this uneven biogeographical distribution pattern of this family is not probably a reflection of the real diversity of the group and may be explained by sampling effort of researchers because philichthyids are usually overlooked during fish dissections (Boxshall & Halsey, 2004; Madinabeitia & Iwasaki, 2013).

According to Grabda (1991), *Colobomatus* spp. display a strict host specificity, typically utilising a single host species or rarely two species. Based on the investigations into *Colobomatus* spp. infecting sillaginids in the Indo-West Pacific, Hayward (1996) disagreed with Grabda's generalisation and suggested that most species of this genus are not specific to host species but to host genera or families. It may be reasonable to consider that copepods of *Leposphilus* have the same patterns of host specificity because *L. labrei* have been recorded from four genera of the family Labridae (see Remarks), supporting Hayward's suggestion. The new species described here is the first member of *Leposphilus* reported from the American Atlantic Ocean and from a host of the Sciaenidae, thus more studies are needed on the taxonomy and host specificity of philichthyids to clarify the magnitude of strictness of host specificity and the real diversity of this family, which yet remains a poorly known group of parasitic copepods and might be more abundant than previously thought.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All applicable institutional, national and international guidelines for the care and use of animals were followed.

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